

2012 Project ~~X~~ Physics Study

Large Area Picosecond Photo-Detectors

Andrey Elagin



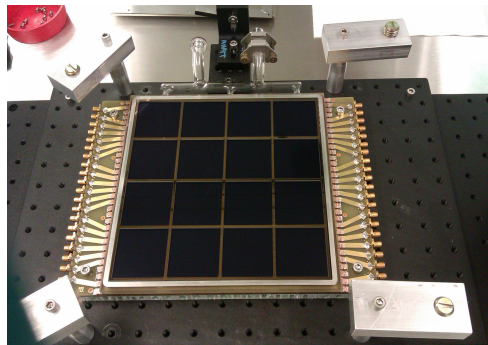
THE UNIVERSITY OF
CHICAGO

on behalf of the LAPPD collaboration

- *Introduction*
- *LAPPD status*
- *Conclusions*

June 16, 2012

Large Area Picosecond Photo Detectors (LAPPD)



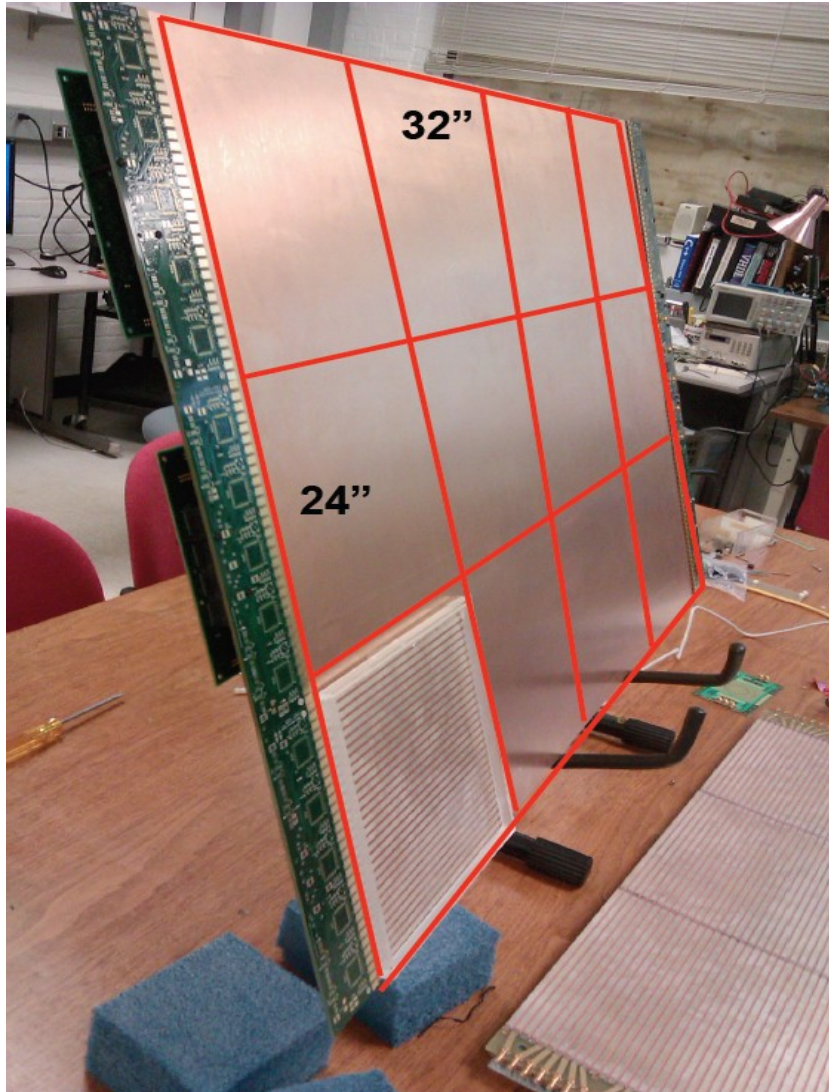
Goals:

- *Large area*
- *Picosecond timing*
- *Cheap*

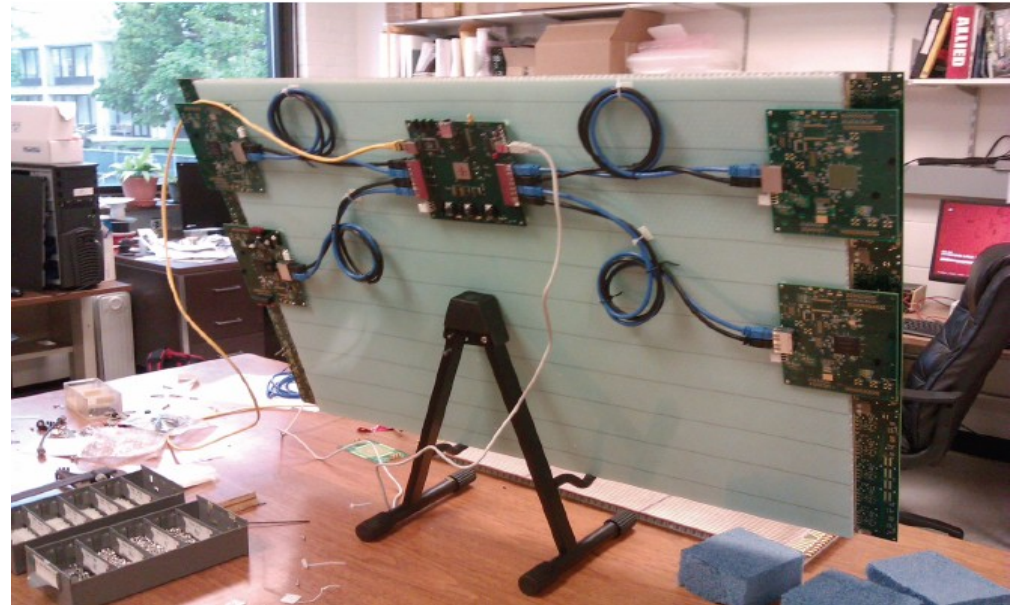
Applications:

- **Picoseconds on large area**
- *Neutrinos*
- *Kaons*
- *Collider*
- *Muon cooling*
- *PET scan*
- *X-ray*
- *Neutrons*

Super Module

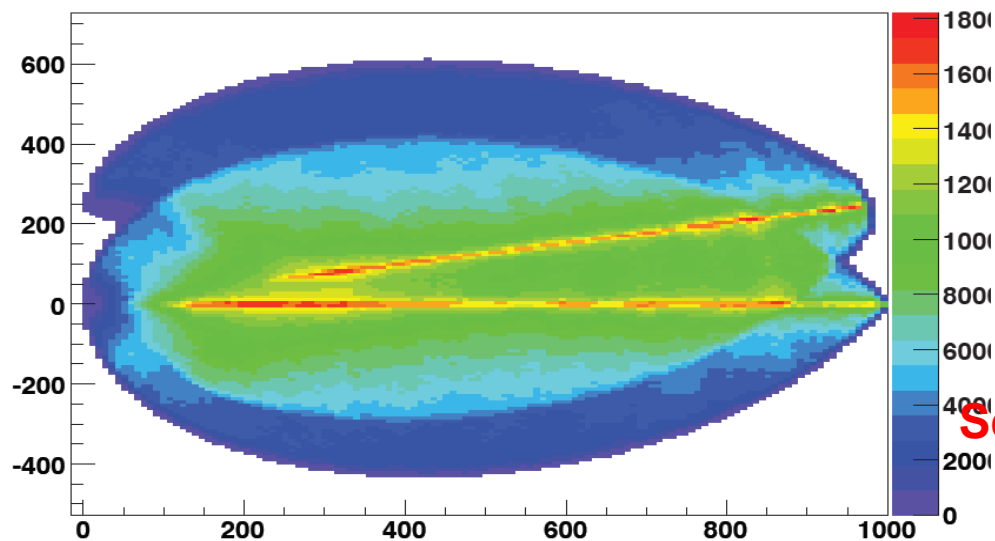
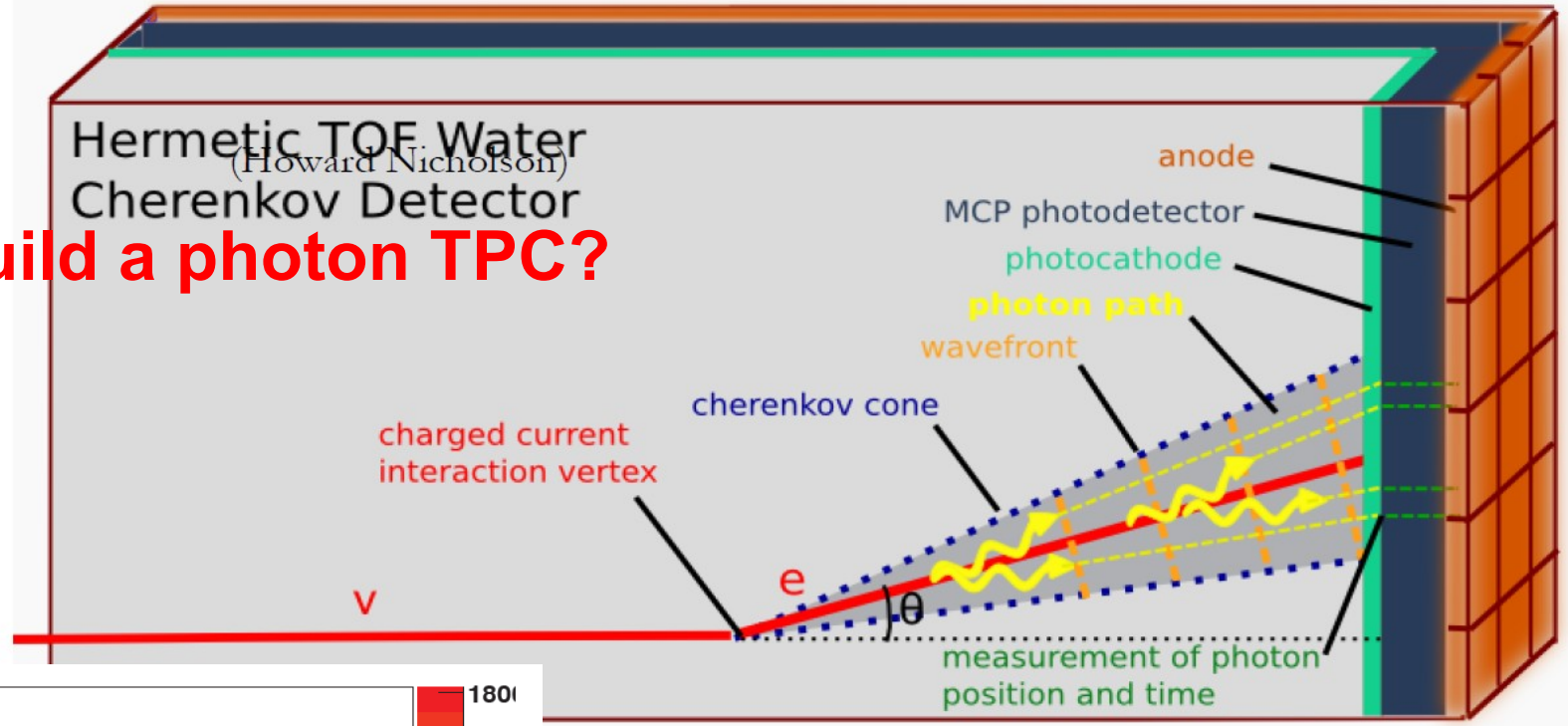


- *Thin planar glass body detector*
- *MCPs share single delay line anode*
- *Fully integrated electronics*



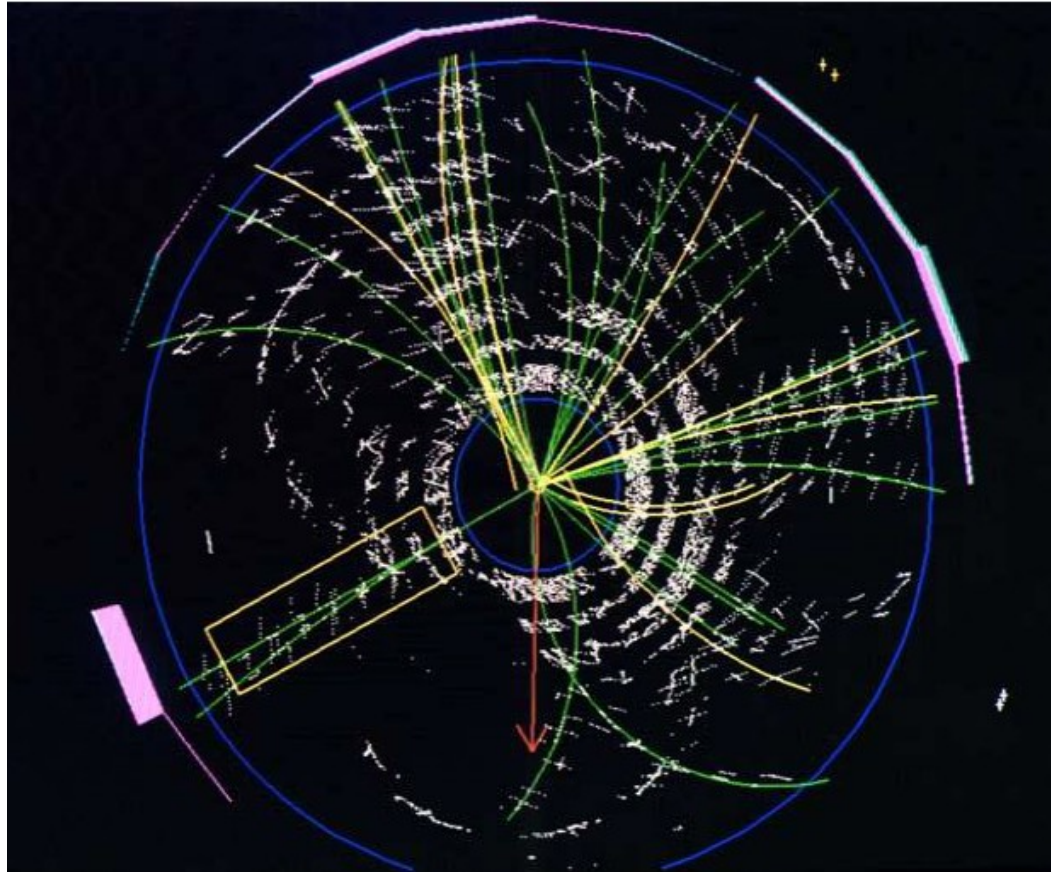
Non-Cryogenic Liquid Detector

Can we build a photon TPC?



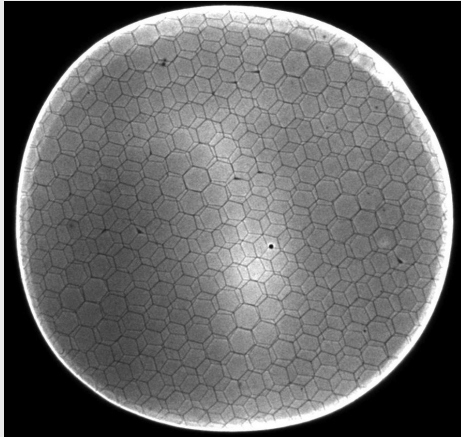
See Matt Wetstein talk on Monday

Can we start talking about particles instead of jets?



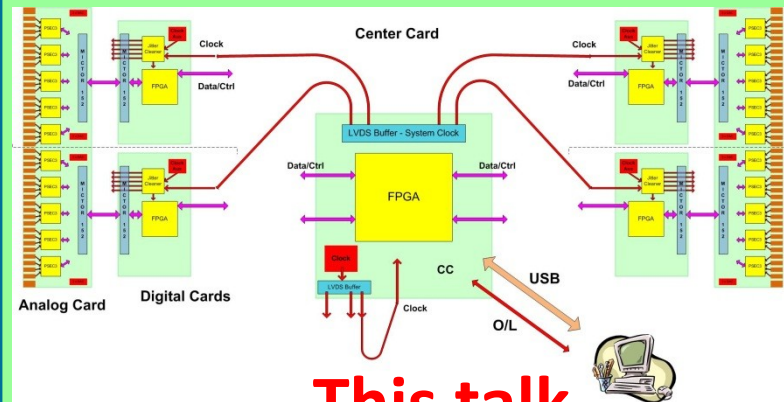
LAPPD components

MicroChannel Plates



This talk

Electronics/Integration



This talk

Hermetic Packaging

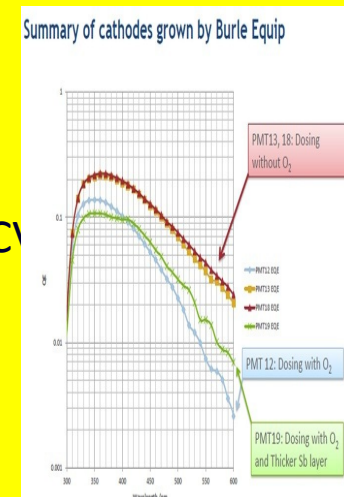


This talk

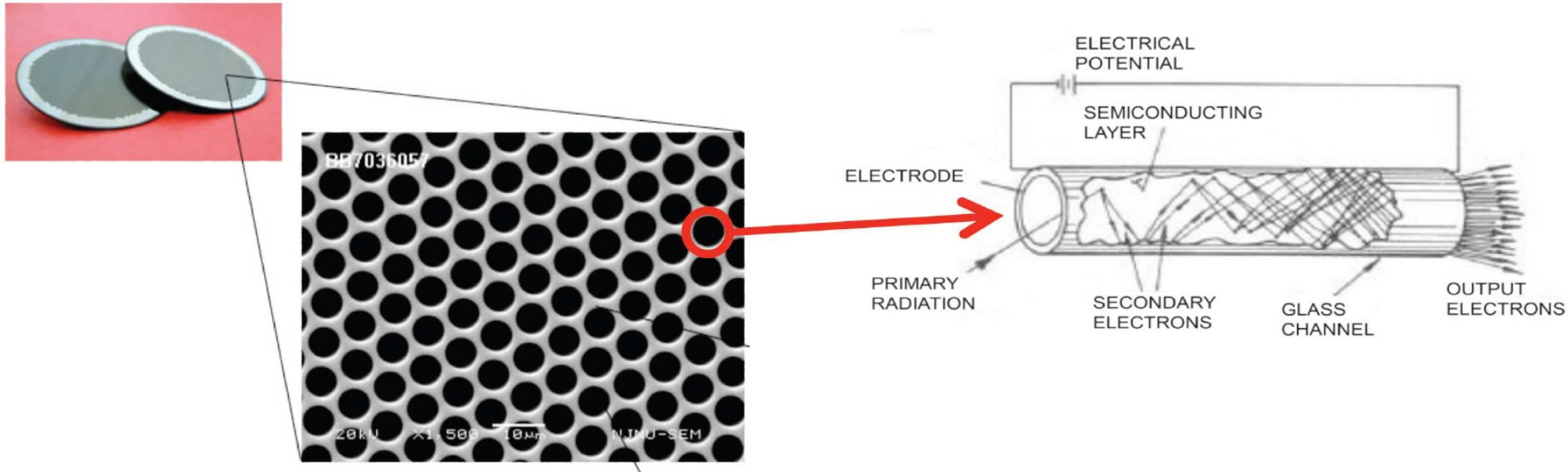
Photocathodes



Next talk



MCP fundamentals

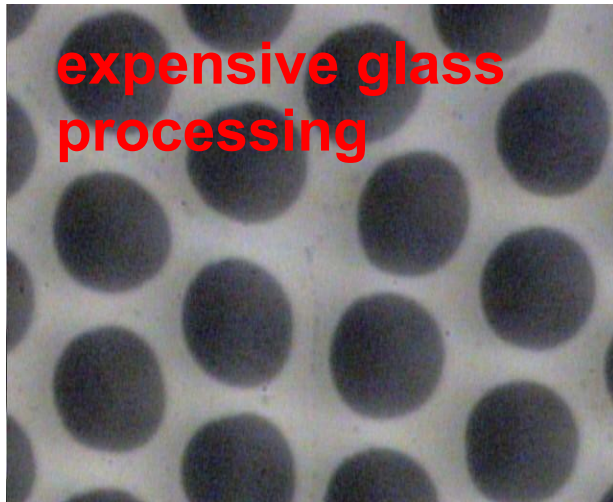


Many electron multipliers per unit area

- Glass substrate with micron pores
- Each pore acts as an electron multiplier
 - *secondary electron emission (SEE)*
 - *high voltage applied*
- **Usually very expensive**

Commercial MCP vs LAPPD MCP

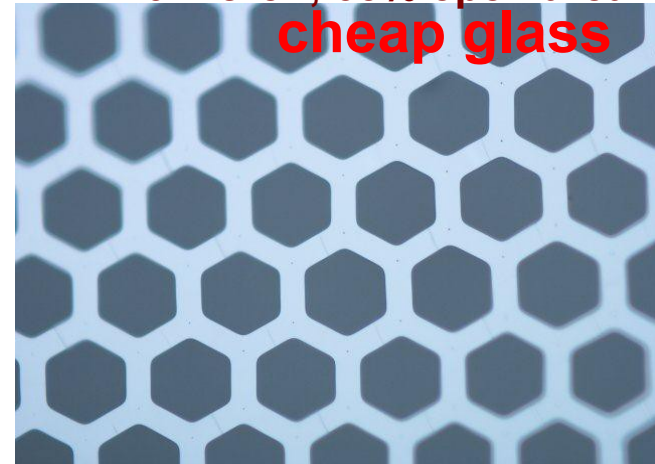
Conventional Pb-glass MCP



Three functions in one glass plate

- *Pores*
- *Resistive layer to provide electric field in the pore*
- *Pb-oxide layer serves as SEE layer*

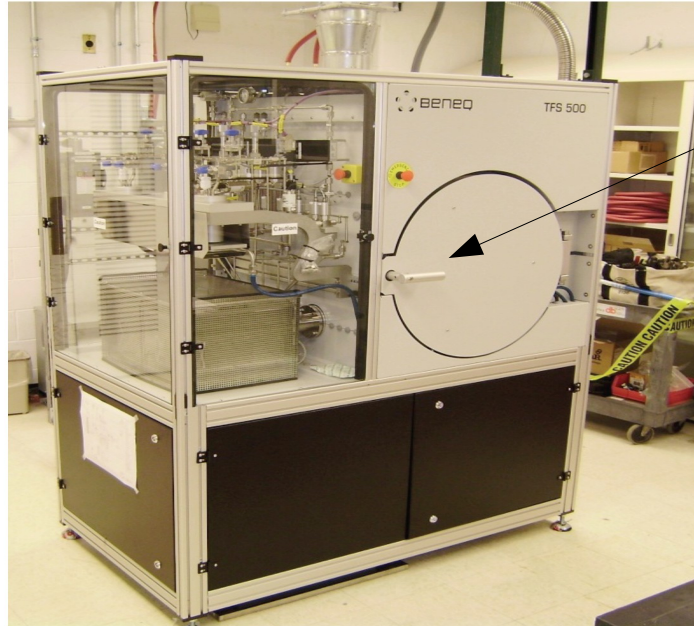
Incom glass substrate D~20micron, 65% open area



Separate the three functions

- *Pores ($L/D \sim 60$)*
- *Resistive layer applied using Atomic layer deposition (ALD)*
- *SEE layer applied using ALD*

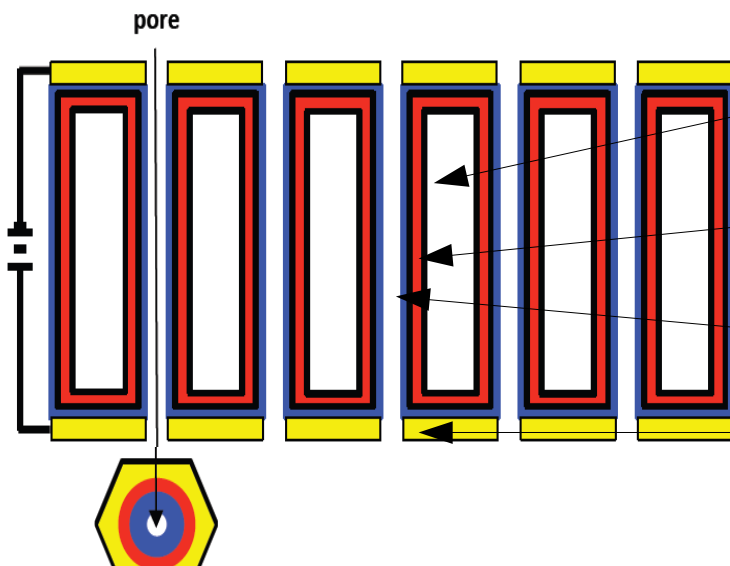
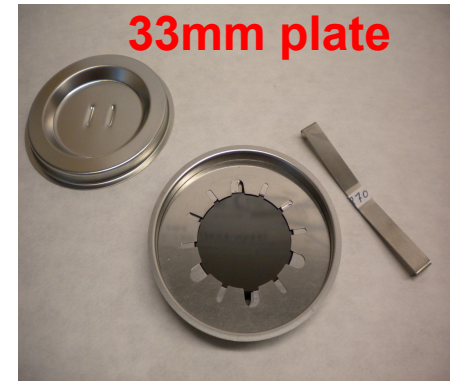
MCP by Atomic Layer Deposition (ALD)



Beneq reactor for ALD
@Argonne National Laboratory

Wide parameter space:

- relative composition of materials
- temperature
- different materials and thickness

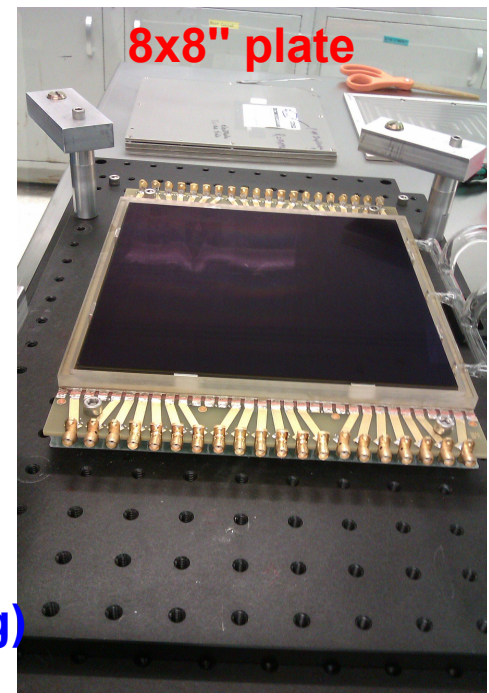


Porous glass

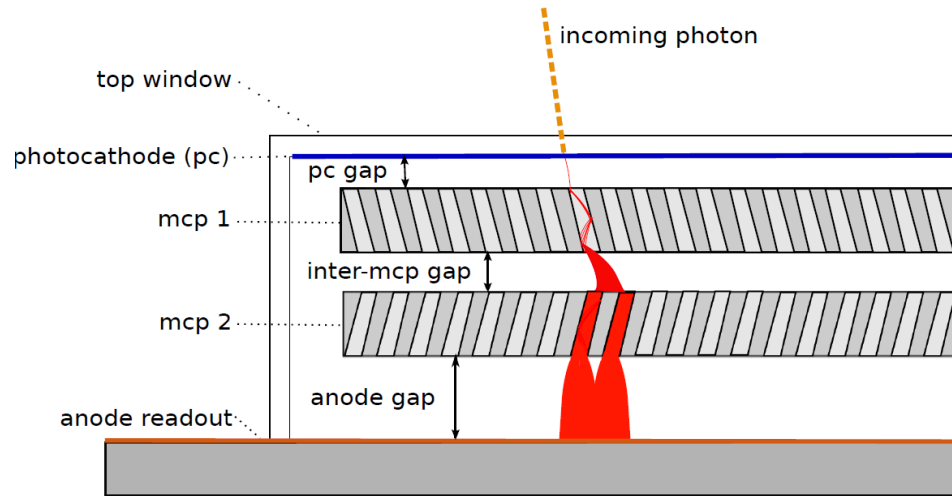
Resistive coating ~100nm (ALD)

Emissive coating ~ 20nm (ALD)

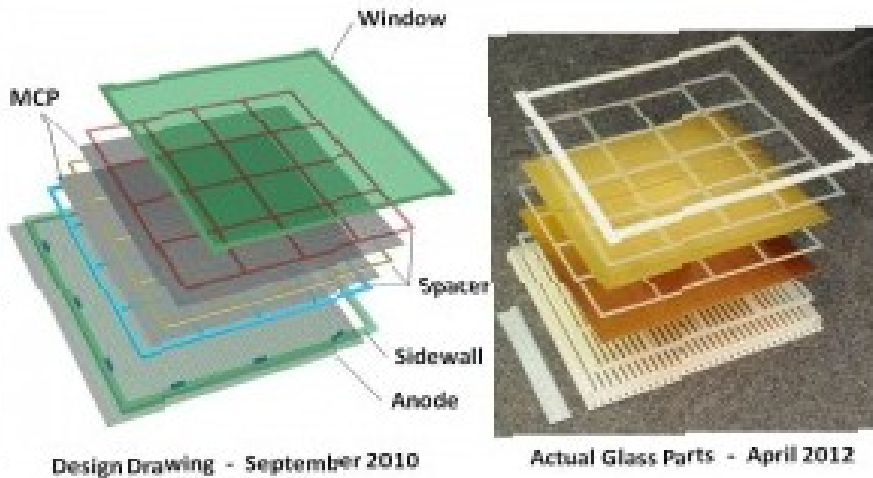
Conductive coating
(thermal evaporation or sputtering)



LAPPD vertical slice



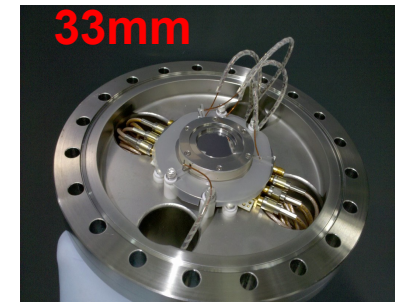
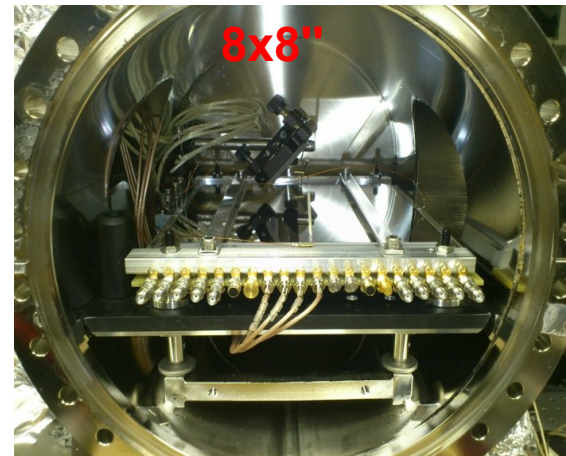
- Enclosed in vacuum ($10^{-7} - 10^{-8}$ torr)
- Photocathode (aluminum at the moment; low quantum efficiency is compensated by high UV light intensity)
- Stack of MCP plates
 - Chevron geometry (8° bias angle)
 - $\sim 1\text{kV}$ across each MCP
 - $\sim 200\text{V}$ across gaps
- Anode (delay line 1.6 GHz bandwidth)
- Readout with high bandwidth scope or LAPPD made DAQ



Design Drawing - September 2010

Actual Glass Parts - April 2012

The Frugal Tile

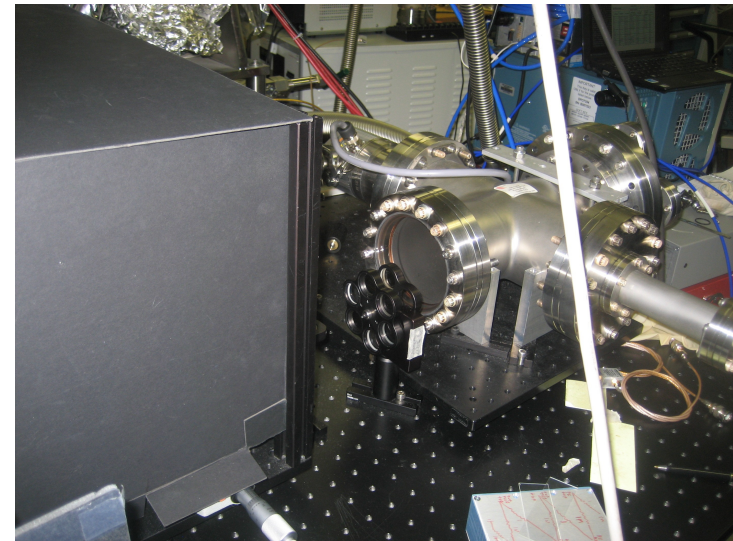
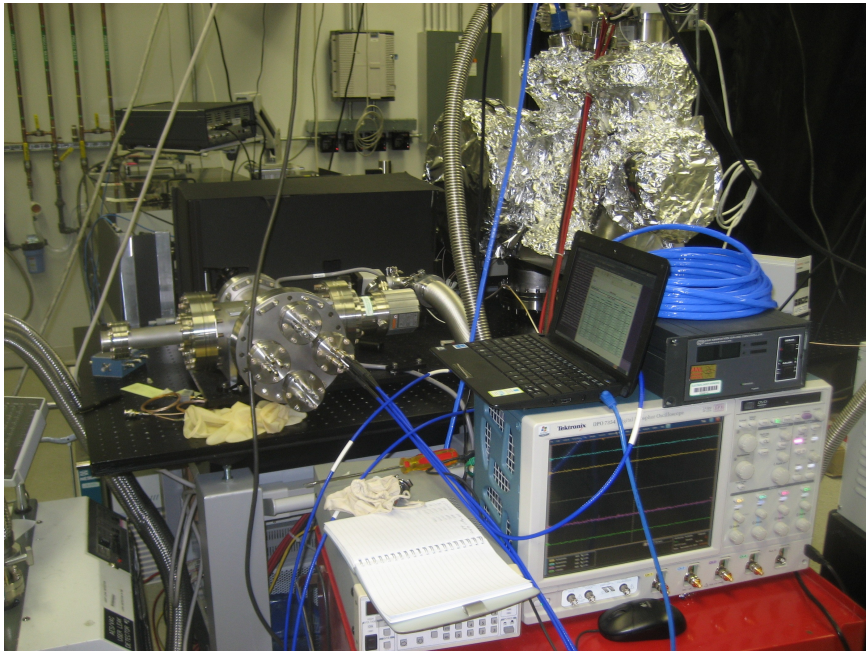
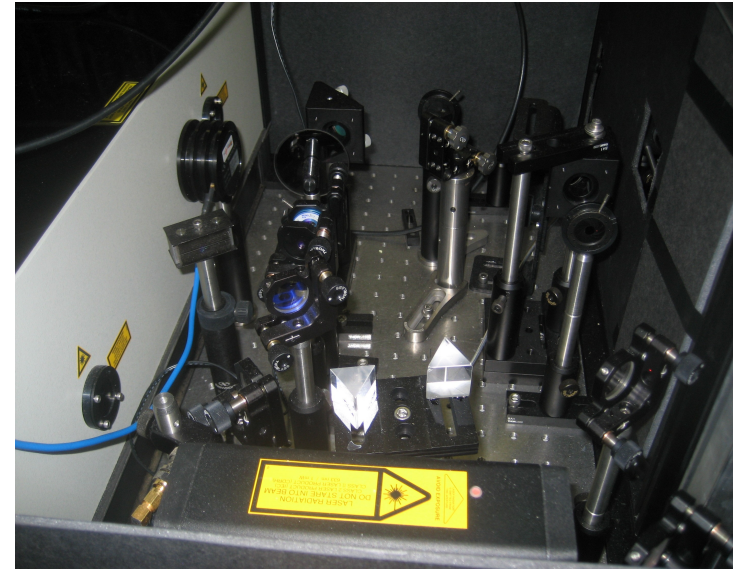


Laser Testing Setup

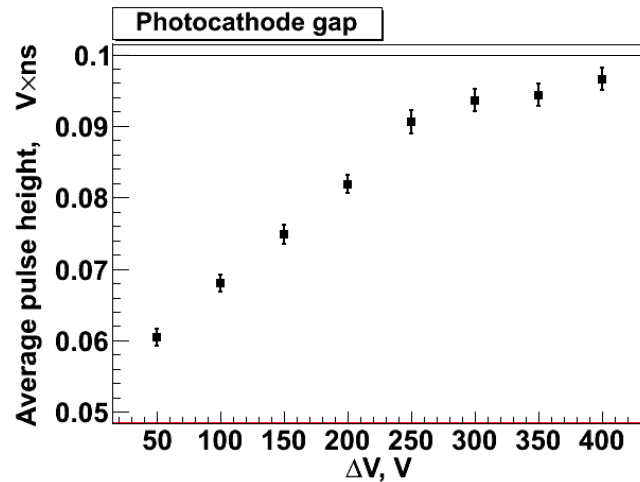
@ Advanced Photon Source Division (APS)
Argonne National Laboratory

Sub-picosecond laser

- Ti:Sapph 800nm; power ~ 800 mW
- pulse duration $O(10)$ femtoseconds
- 1KHz repetition rate
- Non-linear optics to produce
- 266nm UV light

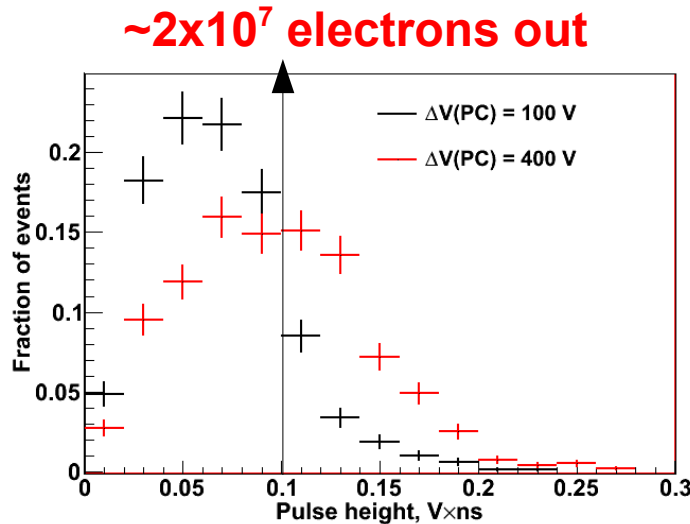
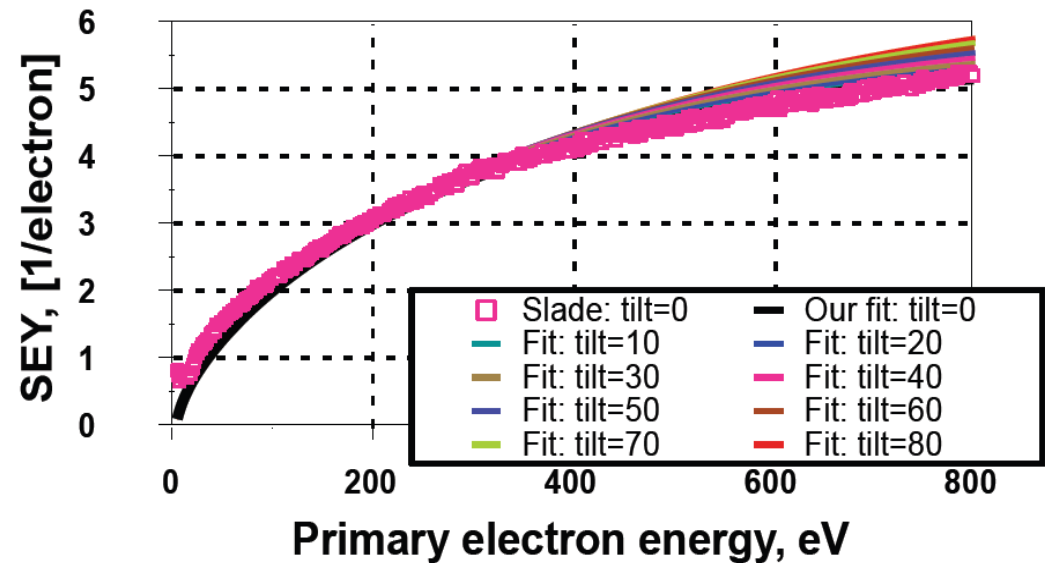


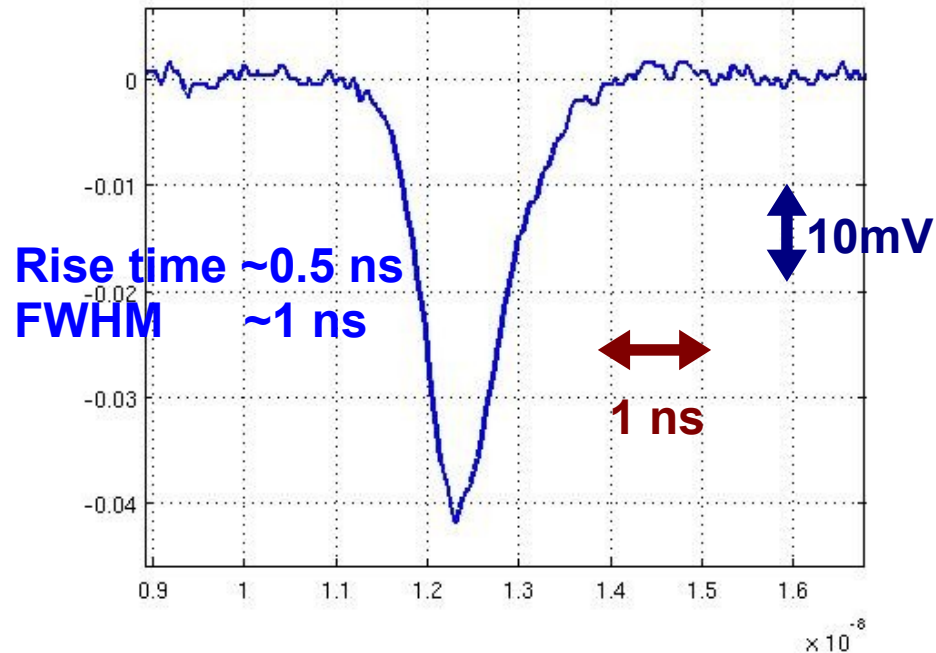
pair of 40 MOhm 33mm MgO plates



$\sim 2 \times 10^7$ electrons out

20 nm MgO SEY data





Timing analysis approach

- Fit rising edge
- Use constant fraction discriminant

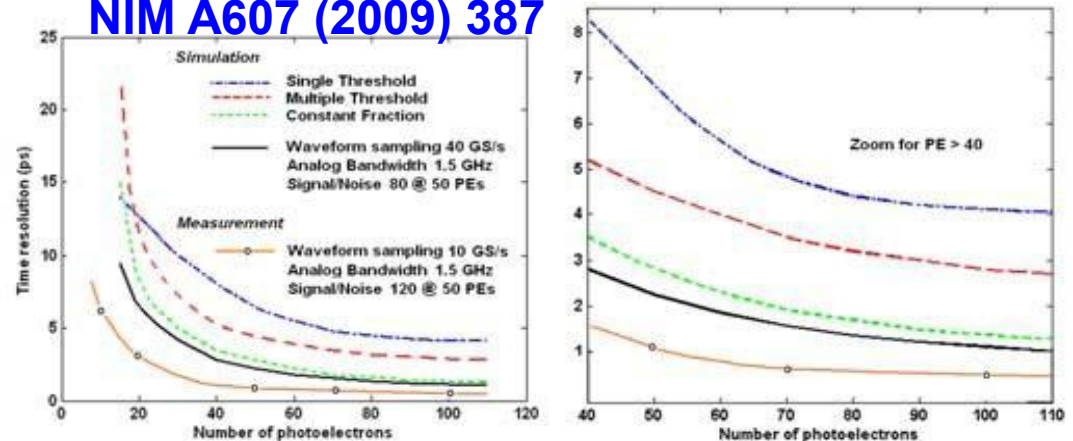
Questions

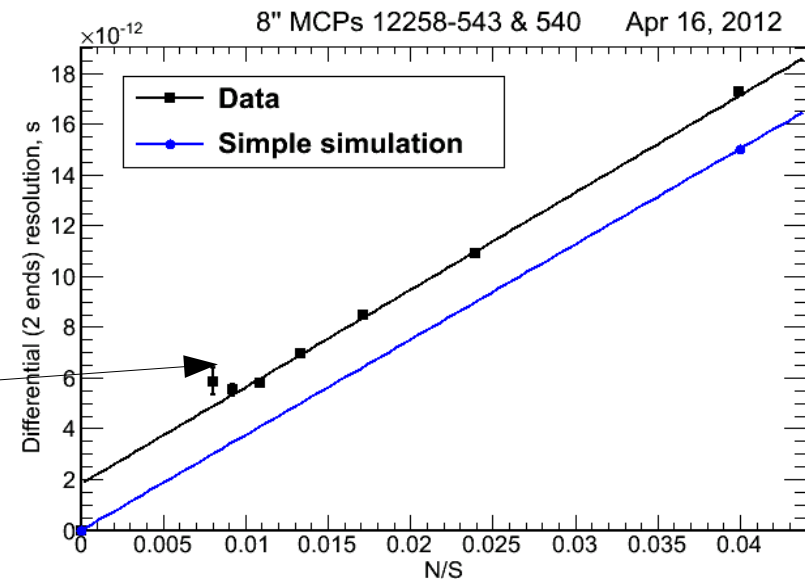
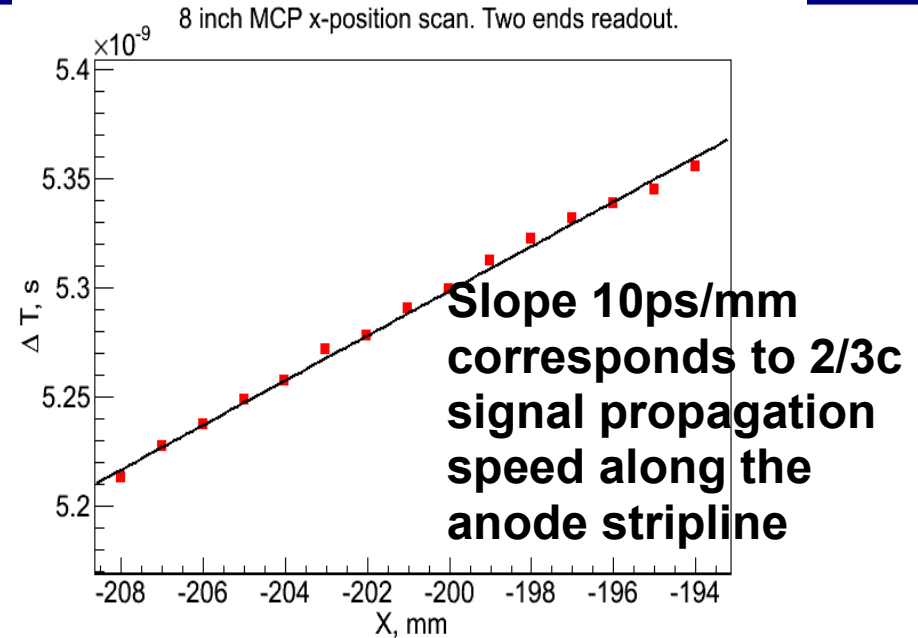
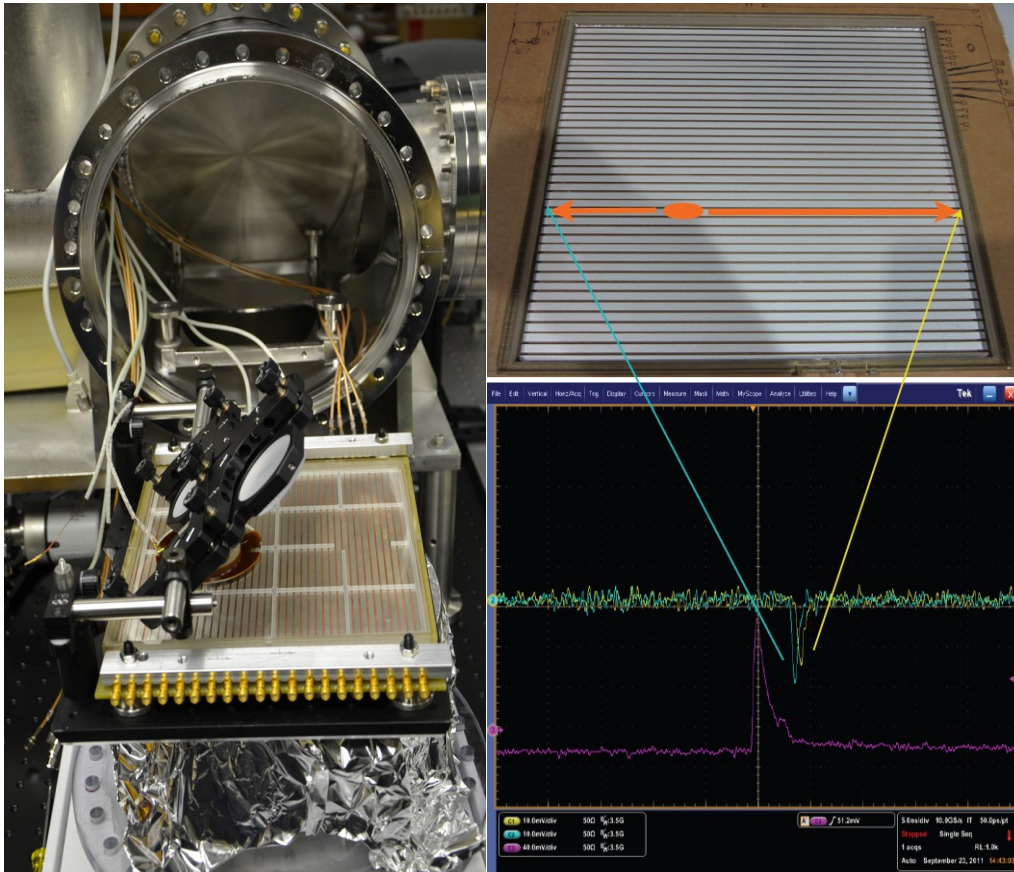
- Time resolution
- Position resolution

Time resolution determinants:

- 1) Signal to noise
- 2) Analog Bandwidth
- 3) Sampling rate
- 4) Signal statistics

NIM A607 (2009) 387





6 ps in $\Delta T \rightarrow 0.6 mm$ in ΔX

See Monday talk at TOF section for more info

Hermetic packaging

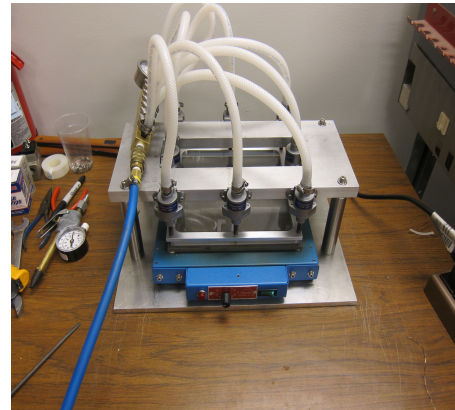
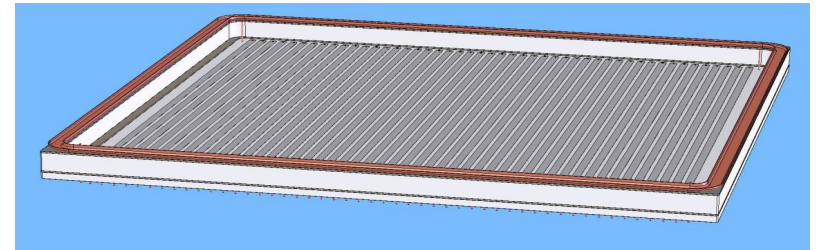
- 1) Glass sidewall over the anode plane: **solved by frit sealing**
- 2) Top window over the full vertical slice: **work in progress**

Primary path for the top seal: indium seal

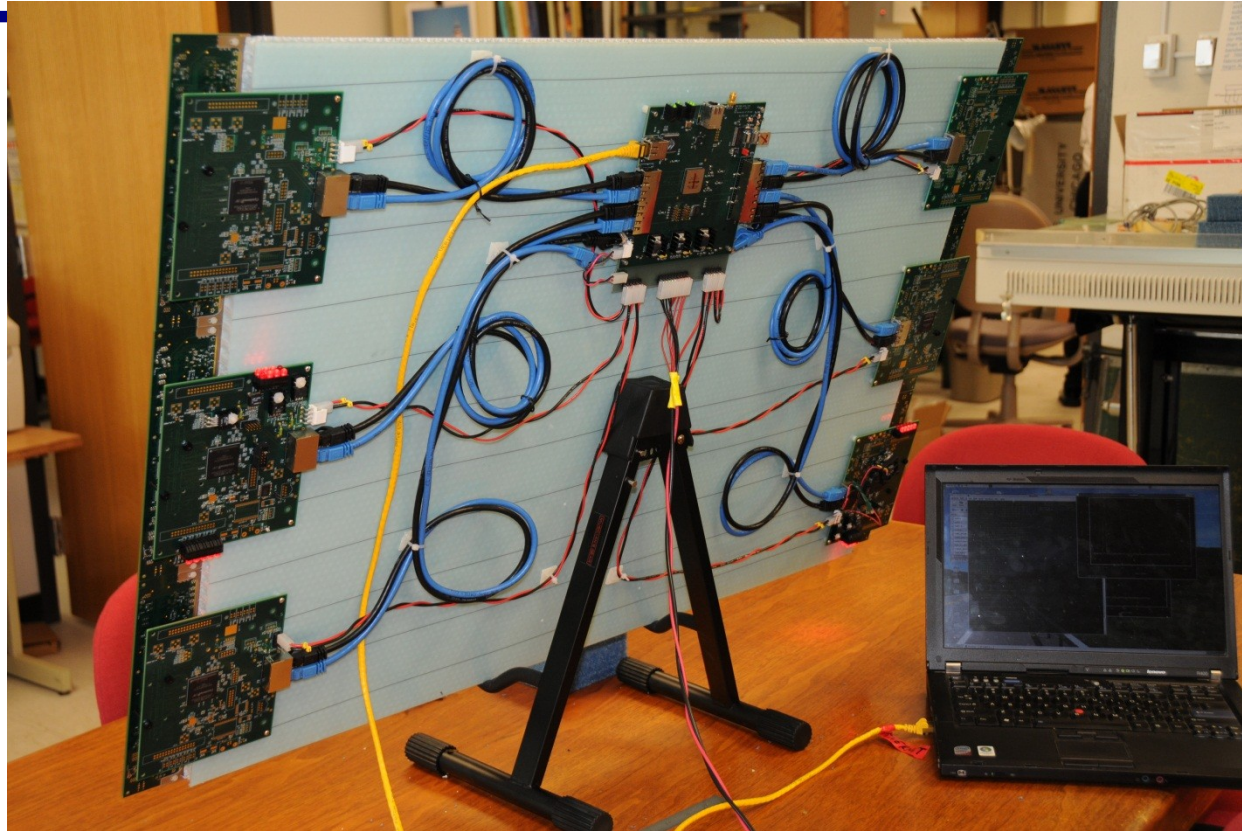
ANL & UChicago effort
glass body



Production Facility at SSL/UCB
ceramic body



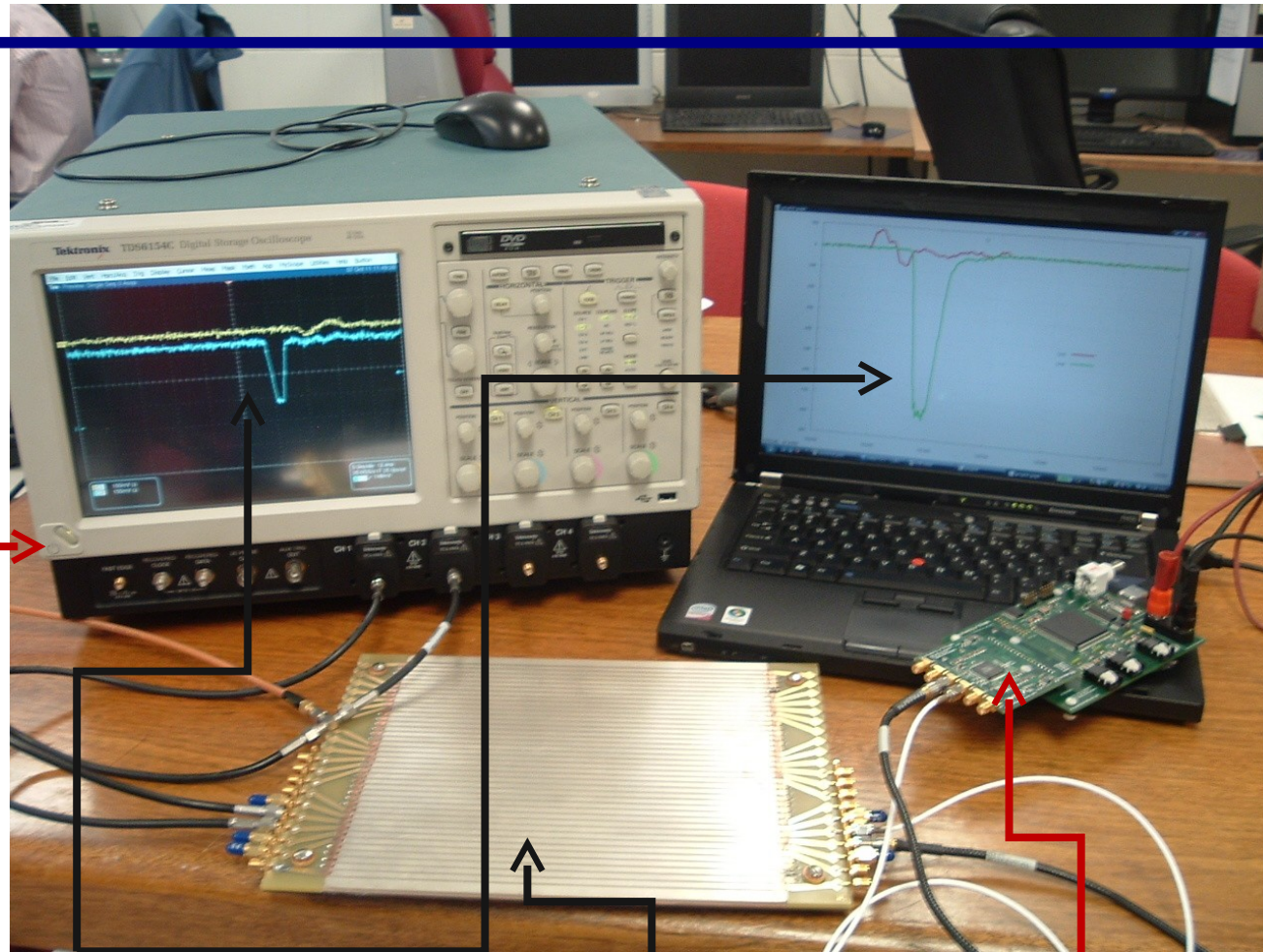
Parallel path: learn from industry (there are plenty vacuum sealed products around)



- **Analog card (PSEC4 chip) for every 6 channels:**
 - waveform sampling
- **Digital card (FPGA) for every 5 chips (30 channels):**
 - charge, time, shape
- **Central card (FPGA) 1 per supermodule:**
 - time and position; system control, CPU interface

Scope-on-a-chip

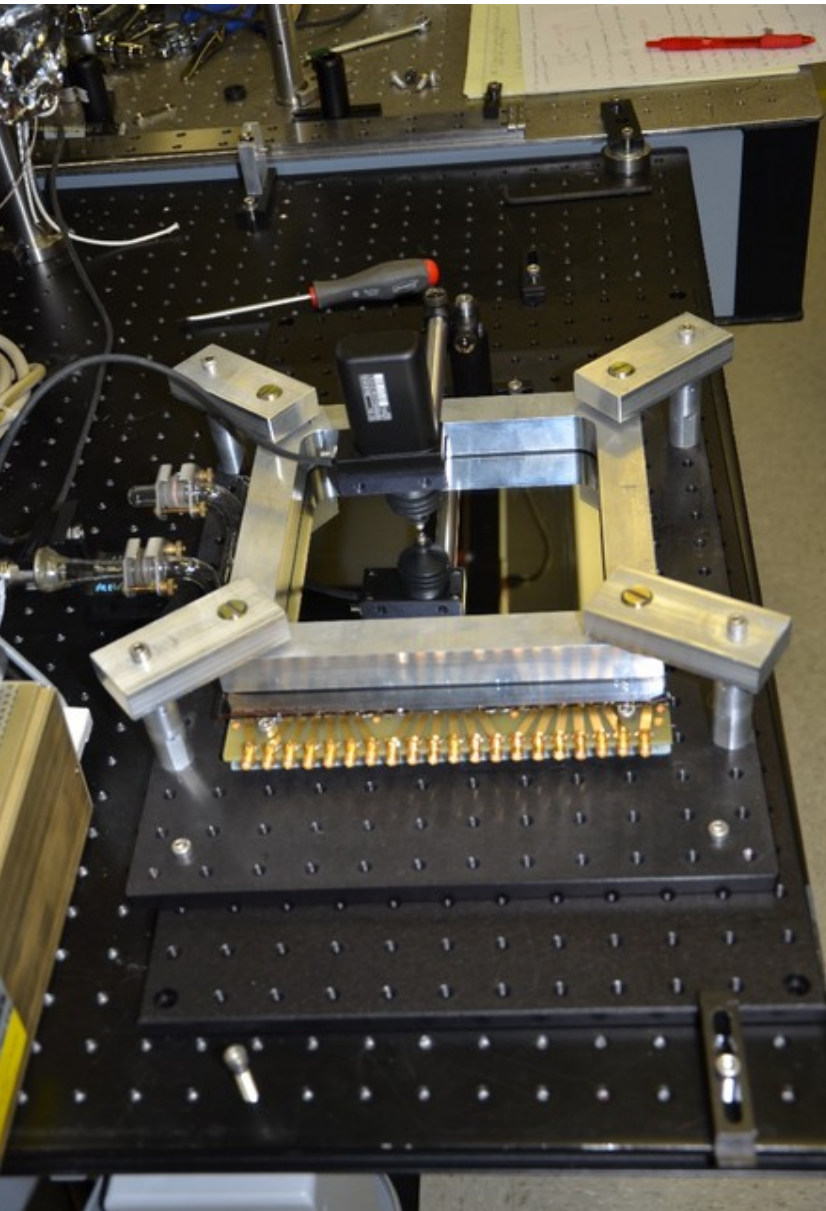
Designed by Eric Oberla (UC grad student)



Real digitized traces from anode

20 GS/scope
4-channels (142K\$)

17 GS/PSEC-4 chip
6-channels (\$130 ?!)

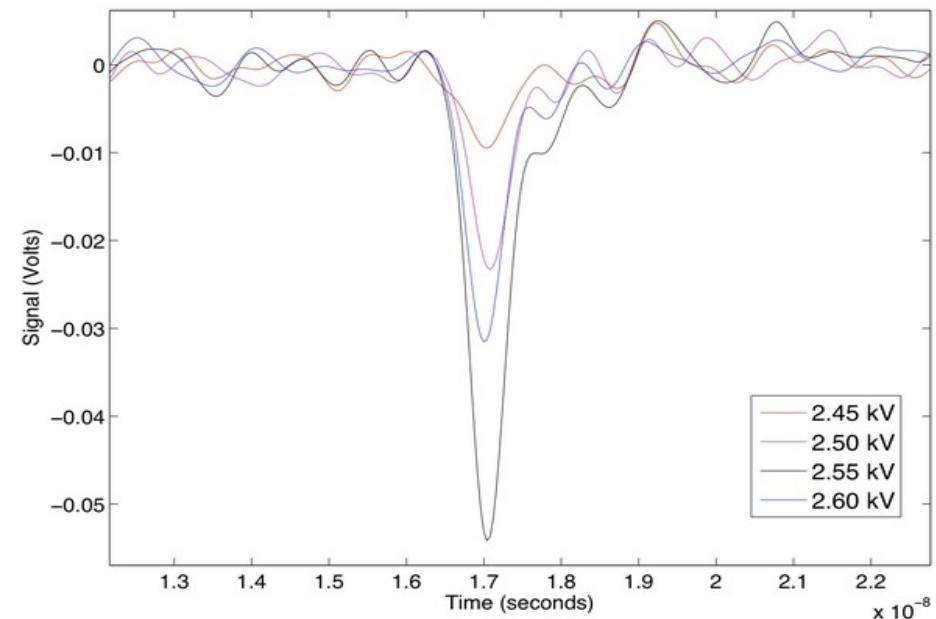


„Sealed tube“ prototype

- full vertical slice
- data taking using LAPPD made electronics

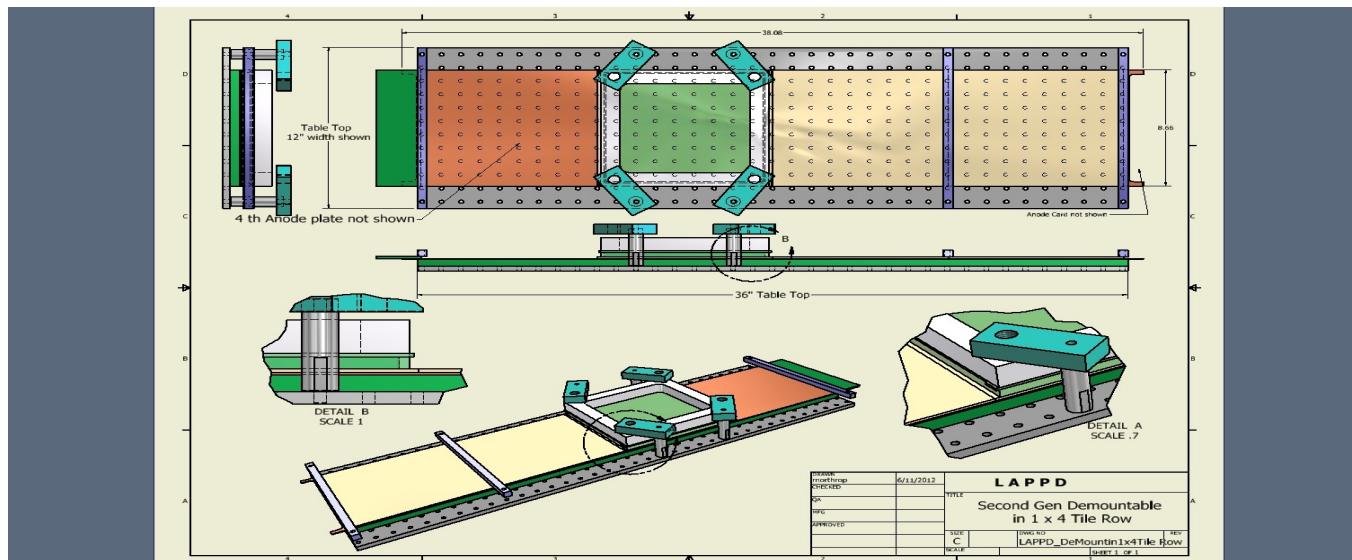
What's different from final design

- active pumping
- aluminum photo-cathode



- Approaching picosecond domain on large area
- Demountable prototype shows very promising performance
- Major challenges: photo-cathode & top seal
- Next steps:
 - many... **photo-cathode and top seal are crucial**
 - testing of the super-module with fully integrated DAQ
 - see our plans and progress here

<http://psec.uchicago.edu/> and <http://psec.uchicago.edu/blogs/lappd/>



Back-up

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Play
YouTube
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Search
About 1,680,000,000 results (0.08 seconds)

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Project X - Warner Bros.
projectxmovie.warnerbros.com/
Project X follows three seemingly anonymous high school seniors as they attempt to finally make a name for themselves. Their idea is innocent enough: let's ...

Project X (2012) - IMDb
www.imdb.com/title/tt1636826/
★★★★★ Rating: 6.6/10 - 26840 votes
3 high school seniors throw a birthday party to make a name for themselves. As the night progresses, things spiral out of control as word of the party spreads.
Directed by [Nima Nourizadeh](#). Starring [Thomas Mann](#), [Oliver Cooper](#).
↳ [Full cast and crew](#) - [Release dates](#) - [Trivia](#) - [Parents Guide](#)

Project X (2012 film) - Wikipedia, the free encyclopedia
[en.wikipedia.org/wiki/Project_X_\(2012_film\)](http://en.wikipedia.org/wiki/Project_X_(2012_film))
Project X is a 2012 comedy film directed by Nima Nourizadeh in his feature film debut, written by Michael Bacall and Matt Drake based on a story by Bacall, and ...
↳ [Alexis Knapp](#) - [Trouble on My Mind](#) - [Nima Nourizadeh](#) - [Michael Bacall](#)

Project X

Project X is a 2012 comedy film directed by Nima Nourizadeh in his feature film debut, written by Michael Bacall and Matt Drake based on a story by Bacall, and produced by The Hangover director Todd Phillips. Wikipedia

Initial release date: March 1, 2012

Director: [Nima Nourizadeh](#)

Running time: 88 minutes

Music: [John Powell](#)

Story: [Michael Bacall](#)

Cast: [Oliver Cooper](#), [Jonathan Daniel Brown](#), [Kirby Bliss Blanton](#), [Dax Flame](#), [More](#)

Named Projects (large and not so)

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LHC - CERN
lhc.web.cern.ch/
Accelerates proton beams up to the rate of 7 TeV using the facility near Geneva, Switzerland. Includes general overview
6 Google reviews

Route de Meyrin 385 1211 Geneva, Switzerland
022 767 61 11
LHC status, "page 1" - Dashboard

CERN - The Large Hadron Collider
public.web.cern.ch/public/en/lhc/lhc-en.html
The **Large Hadron Collider (LHC)** is a gigantic scientific spans the border between Switzerland and France about

CERN - LHC Experiments: ATLAS
public.web.cern.ch/public/en/lhc/atlas-en.html
ATLAS. ATLAS is one of two general-purpose detectors wide range of physics, including the search for the Higgs b

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LAPPD
<https://lappd-trac.uchicago.edu/>
A group of us from The University of Chicago, Argonne, Fermilab, Hawaii, and Berkeley are interested in the development of large-area systems to measure the ...

LAPPD Software
psec.uchicago.edu/blogs/software/
LAPPD Software. Notes on Software for **LAPPD Project.** **LAPPD Software Blog.** Wednesday 31 August 2011 - Filed under Uncategorized. This blog has a plugin ...

LAPPD ID Lab Project Page
www.phys.hawaii.edu/~idlab/taskAndSchedule/LAPPD/LAPPD.html
LAPPD Electronics Microgroup (ID Lab page) Further comments on **LAPPD NSS draft** (Jean-Francois)? PSEC3 paper updates (Eric); Action items from last ...

LAPPD Photocathode godparent Committee Home
www.phys.hawaii.edu/~varner/PC_gc.html
Oct 12, 2010 - Indico page [link to be updated -- still pointing to last review] Fourth Godparent Committee review will held Tuesday, July 10th at ANI

Darien, IL
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